Ontario

Ministry of Transportation
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Construction of Longitudinal Joints In Flexible Pavements - Design Guidelines

MERO-033

Technical Report Documentation Page

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Abstract	Improving the durability of asphalt pavements is an on-going goal to the Ontario Ministry of Transportation and the hot-mix industry. One way to achieve this goal is to construct proper longitudinal joints. While proper construction techniques are important in contributing to the quality of a longitudinal joint, increased awareness of the issues which should be considered during the planning and design of projects plays an equally important role in producing desirable joint quality. This report presents a holistic approach to improving the quality of the longitudinal joints which are expected to increase the durability of asphalt pavements.
Key Words	Longitudinal joint, pavement deterioration, echelon paving, planning, design
Distribution	Unrestricted technical audience.

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Table of Contents

Executive Summary

Improving the durability and service life of asphalt pavements is an ongoing goal of the Ontario Ministry of Transportation (MTO), as well as the hot-mix industry. All concerned are continuing to seek out opportunities to improve the quality and durability of asphalt pavements in order to extend their service life. In keeping with this objective, focus is being placed on improving the longitudinal joint quality by eliminating the cold joints and/or using other methods of constructing the joints.

Representatives from MTO and the hot-mix industry (Appendix A) participated in a series of meetings, aiming at developing a holistic approach to the issue of proper joint construction, by exploring possible opportunities related to improving the quality and performance of longitudinal joints.

From the discussion that took place, it was apparent that a number of the issues that impact on quality need to be considered very early in the planning stage. As a result of the discussions at the meetings, this document was developed with the intention of raising the awareness of some of the issues for staff involved in the planning and design stages of projects (Appendix B).

Introduction

Improving the durability of asphalt pavements is an ongoing goal of the Ontario Ministry of Transportation (MTO), as well as the hot-mix industry. Over the past ten years, great strides have been made in the quality of hot mix asphalt in the province of Ontario. Three changes in the industry that have had major impacts on improving pavement quality: the switch to performance graded asphalt cement (PGAC); the introduction of End Result Specifications for materials and the adoption of Superpave mix design methodology. While these changes have improved the overall quality of the pavement, poor joint construction, both transverse and longitudinal, may still result in pavements failing to meet the expected design life. All concerned are continuing to seek out opportunities to improve the quality and durability of asphalt pavements. In keeping with the objective of improving pavement quality, focus is being placed on improving longitudinal joints.

During 2007, representatives from MTO and the hot-mix industry (Appendix A) participated in a series of meetings to explore the issues and opportunities related to improving the quality and performance of longitudinal joints. Both ministry and industry recognise that, in order to improve joint construction, not only proper construction practices have to be followed but the paving environment has to be conducive to proper joint construction. As such, the environment has to be built into the contract and consideration given from the time the project is conceived and continued through to the design and construction stage.

This document evolved out of the discussions that took place at the meetings and is intended to raise the awareness of designers regarding the issues that impact on the construction of better performing longitudinal joints. The summary document (Appendix B) that was prepared during the meetings between MTO and the hot-mix industry, identifying some of the key issues influencing pavement constructability and quality, is included as an appendix to this report.

Background

Pavement deterioration is an ongoing problem that impacts on highway maintenance costs as well as driver comfort. While deterioration due to wear and tear of traffic and aging is inevitable, pavement failure due to premature deterioration associated with poor construction joints is preventable. One significant area of premature pavement deterioration is on the surface course of pavement adjacent to construction joints such as the centreline joint. As the joints deteriorate, the distresses in this area often include, single, multiple, alligator cracking and potholing.

The deterioration around the centreline joint is caused by a number of factors. Typically, a longitudinal "cold joint" is formed along the centreline when there is a delay in paving adjacent lanes. As a result, the mix along the joint is usually more porous than the asphalt material away from the joint.

The presence of the cold joint results in poor bonding between lanes. In the initial pass, it is more difficult to properly compact the asphalt pavement in the area along the cold joint because of the free edge. This often results in the level of compaction adjacent to the cold joint being lower than in the main lane of the asphalt pavement. The presence of cracking along with the more porous pavement allows water to migrate into the asphalt pavement. When freezing and thawing occurs, the pavement around the joint begins to experience an accelerated rate of deterioration. Photo 1 shows a newly constructed joint. Photo 2 shows a cold joint after a few years of freeze-thaw exposure.

Photo 1 – Poor Compaction

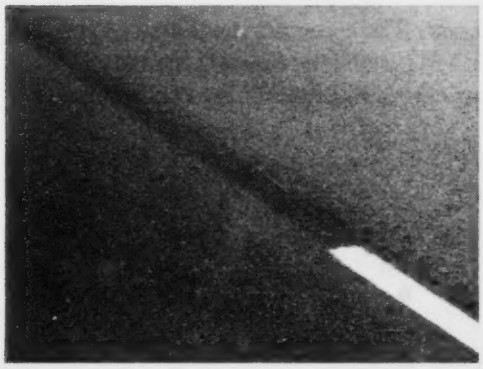


Photo 2 – Cold Joint

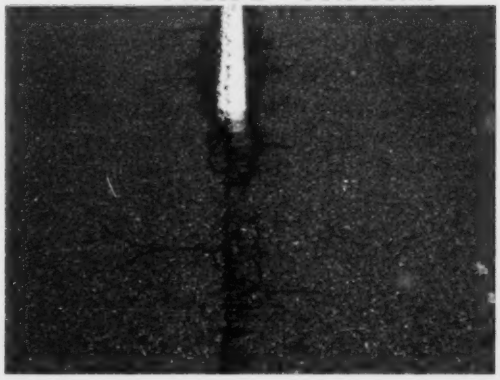


Photo 3 (below) shows an example of pavement deterioration originating at the joint between the left and right lanes.

Photo 3 – Longitudinal Joint Deterioration

If longitudinal joints are eliminated, the maintenance problems associated with the joints are also eliminated. In order to eliminate longitudinal joints, or minimize their number, thought must be given to the issue very early in the planning process and at various stages throughout the design process. This is in addition to the need of using proper construction techniques.

In situations where joints can not be eliminated, thought must be given to opportunities for improving the quality of joint construction. When joint deterioration has begun, ways to arrest the deterioration as early as possible should be considered to prolong pavement life.

Elimination of Longitudinal Cold Joints

Longitudinal cold joints can be eliminated by paving in echelon or paving in tandem. Paving in echelon (Photo 4) is considered to be the optimum method of paving as adjacent lanes are placed within minutes of each other resulting in a hot joint. This short time lag means the pavement in both lanes is still hot and can be compacted simultaneously, resulting in the joint between both lanes being tightly knitted together with uniform compaction across the entire width of the mat. Care is still required to ensure the asphalt material along the unconfined outside edge of the mat is properly compacted. Maximum production rates are usually achieved with echelon paving, which is an additional benefit to planning a project to permit echelon paving. However, production capacity at the plant should be able to match the paving rate of two pavers in order to maximize the benefit of echelon paving.

Photo 4 – Echelon Paving

Paving in echelon is easier to accomplish in some situations than in others. On new highway construction, echelon paving can usually be conducted because traffic and property access do not need to be accommodated. Echelon paving on existing multilane controlled access freeways can sometimes be accomplished by lane closures, lane reductions and partial road closures. Historically, echelon paving has not been carried out on two lane highways because of the need to convey traffic and the need to maintain property access.

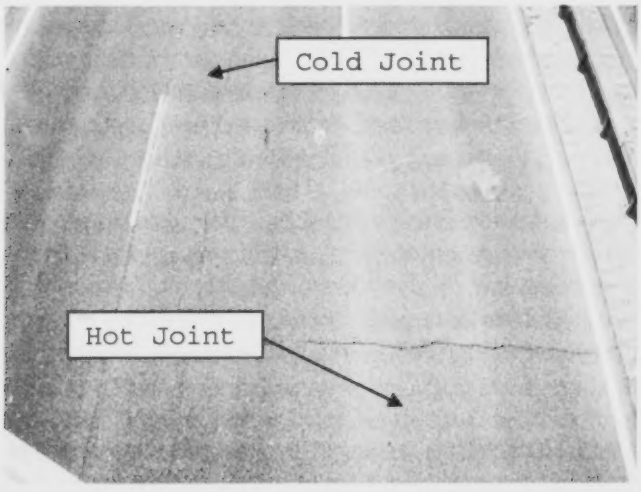
With the large volumes of traffic on highways today one of the biggest challenges is the need to ensure that traffic is properly managed to avoid jeopardizing the safety of the workers or the travellers. Additional steps are often required to ensure traffic cannot enter the work area unless there are specific provisions to handle the traffic such as pace vehicles.

Tandem paving is similar to echelon paving, however the spacing between the two pavers is slightly greater resulting in a warm joint rather than a hot joint. On low volume two lane roads, where detouring traffic is not an option, a traffic control pilot vehicle can be used to guide the traffic over the newly placed mat, and then cross over on to the original road surface between the pavers. While some damage may occur with traffic rolling over the hot edge, the areas of damage can usually be repaired by the workers before the second paver reaches the area. In recent years tandem paving has not been a common practice.

Reasons often cited for not paving in echelon or in tandem include:

- the asphalt quantity was too small to be practical,
- different materials are required on adjacent lanes (i.e. shoulders and mainline lanes),
- inability to close highway and divert traffic to adjacent road network,
- lack of highway capacity to accommodate a reduction in number of lanes,
- operational restrictions (i.e. traffic exposure to milled surfaces for extended periods)
- need to maintain access to property and businesses.

Photo 5 – Longitudinal Joints



These issues will be discussed in greater detail in the following sections. Given the improved longitudinal joint, designers should seek opportunities to provide the option of

echelon paving or mandate its use in contracts. Photo 5 above shows a joint paved in echelon and a cold joint approximately four years after construction. Pavement with joints produced between lanes paved in echelon will be expected to out-perform ones with cold joints.

SMALL QUANTITIES

In order for echelon paving or tandem paving to be a cost effective option, the quantities of asphalt material to be placed must be sufficiently large. This allows the cost of mobilizing the additional equipment and staff to be distributed over the quantity of material. In some cases, particularly with tandem paving, there may be additional costs, such as traffic control pilot vehicles, that also have to be offset in the cost of the project.

The premium cost for tandem paving is similar to that for echelon paving. In general, echelon paving is not practical on projects with less than 10,000 tonnes of asphalt material.

MATERIAL CHOICES

In some cases joints are required because different materials are placed on adjacent areas. This often occurs on freeways when the driving lanes are designed with a higher traffic category and are paved with premium mixes and the shoulders are paved with a less expensive mixes.

Shoulders that are narrower than 1.5 m can typically be placed simultaneously with the main lane, using one paver. If a different mix is required on the shoulder, the opportunity to place the driving lane and shoulder simultaneously is lost. This will reduce the overall efficiency of the project which will be reflected in the cost of some of the contract items. In addition the presence of the cold joint increases the potential for problems with the joint, thereby reducing the performance of the pavement and increasing the long term maintenance costs.

With long sections or sections with fully paved shoulders, adding premium mixes to the shoulders may offset the savings generated by any increases in efficiency. A further benefit for using a premium mix on shoulders may be that it contributes to better shoulders for use during traffic diversions during rehabilitation or maintenance work. The issue should be reviewed with staff from the Geotechnical Section and Contracts during the design process.

Regardless of whether the shoulders are paved simultaneously with the driving lanes, cracking may occur along the edge of pavement because the shoulders often are not constructed to the full depth of the main lanes and there is a change in crossfall between

the driving lane and shoulder. A well constructed joint will contribute to minimizing and delaying cracking.

Premium asphalt mixes often cost more, but if the lower cost asphalt is only required for a small length of shoulders, eliminating a mix type would eliminate the cost of a mix design and the associated operation costs. This also reduces the potential for mixes to be placed in the wrong areas during construction.

When a contractor is required to switch mixes during a paving operation, up to two hours of production can be lost. This in turn increases the cost of the paving operations due to the increased inefficiencies. If the operation is to be completed in a tight window of time (i.e. during a night time closure), this loss of paving time could have a significant impact on the contractor's ability to complete the work in the window available.

While initially it appears there is a savings when placing lower cost materials in areas such as shoulders, this may not be true with smaller quantities. This issue should be reviewed carefully during detail design with staff from the Geotechnical Section and Contracts Section.

LANE CLOSURES

On multi-lane highways echelon paving can only be accommodated by closing two or more lanes. On highways in larger urban areas, this may mean closing the core lanes and diverting traffic to the collectors, or closing the collectors and diverting traffic onto the core lanes. Outside large urban areas this could result in the need to close the highway to traffic in one direction and detouring traffic onto local roads. While this seems like a simple task, the potential for closures needs to be identified during the planning phase of the project so that it can be addressed during the environmental approval process for the project. This provides affected property owners and businesses abutting the project and individuals living along potential detour routes an opportunity to raise any concerns they may have. Concerns that are often raised with detour routes include noise, dust, impeded property access, hazardous materials transportation, and school zones etc. Where roads from another jurisdiction may be impacted by increased traffic, it is important to ensure that the other jurisdiction is aware of the planned detours, so that any work they may have planned can be co-ordinated with the ministry's project.

When evaluating lane closures/reductions and detours, the prevailing traffic volumes must be considered. On multilane freeways approximately 1100 vehicles per hour can be accommodated per lane. This is subject to some variation from region to region because of driver expectations and factors such as interchange spacing. The Regional Traffic Section should be consulted to determine the prevailing traffic volumes and lane capacities that are appropriate for the area of the planned work.

During short-tem closures, a large percentage of the time is spent setting up and removing traffic control. When short-term closures are being contemplated, the project details should be discussed with staff from the Traffic Section and Contracts Section to help assess the most appropriate way to structure the timing restrictions. In some cases there may be the opportunity to extend the daily window for paving in order to complete the work in a fewer number of days and reduce overall costs associated with closures. This may be a key consideration with late year paving when weather becomes more questionable.

On multilane facilities timing restrictions should be indicated per lane. This will allow the contractor to start the process of moving equipment into place on the shoulder, even if sufficient lateral space is not available to accommodate the paving operations that will result in increasing portion of closure that can be dedicated to paving operations.

If it is necessary to divert traffic off a freeway at an interchange, through a signalized intersection, the typical volume that can be accommodated is approximately 850 vehicles per hour per lane. This is based upon the assumption that 50% of the traffic signal green time will be available to the ramp traffic. It should also be noted that the capacity of the intersection varies slightly from region to region because of traffic composition, driver characteristics and other prevailing conditions. It may also be possible to modify the traffic signal timing temporarily to improve traffic operations during planned work. This should be discussed with the regional Traffic Section during the planning phase of the project. Consultation with the Environmental Unit is also recommended.

On a two lane road where flagging or pilot vehicles are being used to control traffic approximately 800 to 850 vehicles can be accommodated per hour, per lane without causing significant delays to traffic. Aside from the temporary signing required in OTM Book 7, no additional signing would be required in most cases.

In some cases the paved shoulders may be sufficiently wide to carry traffic; however the Geotechnical Section should be consulted to confirm if the shoulder pavement has sufficient structural capacity. In cases such as where future expansion is anticipated or other future works may be planned, there may be benefits to improving the shoulders to accommodate traffic. Traffic should not be diverted onto gravel shoulders because of safety concerns related to width, dust and vehicle handling.

Generally it is not cost effective to construct median cross-overs solely to accommodate paving operations. However, there may be situations where cross-overs are needed to promote the quality and efficiency of construction, these benefits should be considered and weighed against the cost. If such cross-overs are constructed to carry highway traffic, traffic control will require special consideration.

When lane closures are required to accommodate paving work, it is advisable to contact the OPP and local police services as well as emergency services during the planning phase of the project to advise them of the proposed work. It is also advisable to contact

emergency services a month or so prior to the start of construction to update them on the details of the planned work. School boards should also be contacted if complete closures are planned to allow them an opportunity to adjust bus routes.

Notification of the public prior to the paving operations is key to minimizing the impact on traffic. Often the notification can include media notification such as radio and local newspaper, but may also include the use of Portable Variable Message Signs (PVMS) to provide "real-time" notification just prior to the closures. The Regional Traffic Section should be consulted prior to including provisions for PVMS in the contract.

NIGHT CLOSURES

If paving in echelon is to be carried out on some facilities it may be necessary to pave at night when traffic volumes are low enough to be handled on the available lanes or on detour routes. In built up areas, this will often require a noise by-law exemption from the municipality to permit the paving work to be carried out. The potential for a noise by-law exemption should be discussed with the municipality during the early planning stages of the project. In rural areas or in jurisdictions without noise by-laws, it is recommended to advise the municipality of the intent to carry out night work and seek their support or acknowledgement. Once again, this should be done early in the project planning stage to help ensure the work can be performed without disruption, and eliminate the need to renegotiate the cost of items in the contract as a result of the nature of the work changing.

The potential for night time paving should be identified and documented during the environmental approval process.

When considering night time paving, temperature must be considered. While it is not uncommon in the early or late part of the year to obtain temperatures above 12°C during the day, temperatures can fall below freezing at night. If night paving is required to accommodate traffic volumes, the night temperatures should be carefully considered. Environment Canada and the Weather network web sites are valuable resources when planning a project.

Artificial lighting should also be considered with night work to improve visibility in the work area. Even with artificial lighting, visual defects such as segregation, flushing and joint construction problems are more difficult to detect. An added benefit of the lighting is that it helps to alert drivers of the work ahead.

Another issue that arises with night paving is the potential location of the hot-mix plant. If the plant is located near noise sensitive areas, it may be subject to restrictions on the hours of operation. Contractors may need to obtain a noise by-law exemption for their plants.

There may be municipal restrictions on trucks using certain routes. As with the noise by-laws, this should be discussed with the municipality early in the project planning stage.

PVMS may be beneficial in alerting traffic to the unexpected conditions ahead. On two lane facilities, use of a remote control flagman or portable traffic signals may be required for traffic control during night-time operations. The regional Traffic Section should be consulted prior to including provisions for PVMS signs or remote control flagmen in the contract.

RESTRICTIONS ON MILLED SURFACES

Except in the case of emergency situations to eliminate pot-holing, MTO traditionally has placed tight restrictions on the duration milled surfaces are exposed to traffic. Safety is the biggest concern when placing restrictions on exposure times for milled surfaces. Vehicles such as motorcycles and cars pulling trailers may find it more difficult to navigate on milled surfaces. The potential for ponding of water is another safety concern for limiting exposure times for milled surfaces. In other situations, the structural capacity of the pavement is an additional consideration in determining an acceptable duration for exposing the milled surface to traffic.

In contracts where milling is required, careful consideration must be given to restrictions on the duration that milled surfaces can remain exposed to traffic. If a contractor is required to pave all milled surfaces by the end of the day/shift, the amount of paving that can be undertaken is greatly reduced because of the need to co-ordinate operations. This will have a significant impact on the cost of the paving operations, because of the inefficiencies that are introduced when the milling and paving operations are required to be coordinated. These types of restrictions have a more pronounced influence on the cost of echelon paving because of the amount of equipment that is involved.

Any water ponding in the driving lanes can significantly impact on vehicle handling. If milled surfaces are permitted to be left exposed, careful consideration should be given to the alignment (horizontal and vertical). In some cases there may be opportunities to improve drainage by carrying out some small amounts of additional milling in low areas to allow water to outlet. Usage of additional signage and temporary speed reductions may help to address concerns about traffic travelling on milled surfaces.

To address concerns about vehicle handling during lane changes due to the vertical difference between adjacent lanes, temporary ramping should be considered.

PROPERTY ACCESS

During paving, the need to maintain property access for businesses and residences must be considered during the design of the project. Preventing traffic from accessing businesses

could result in significant financial claims against the ministry. In some cases, it may be possible to avoid the majority of access concerns by conducting paving operations at night or during the weekend. In heavy tourism areas, there may be an advantage to conducting the work prior to, or after, the peak tourism season.

Enabling Better Longitudinal Joint Construction

Where cold joints cannot be avoided, special attention must be taken during the design and construction to ensure the joints can be properly constructed. The ability of a contractor to easily and efficiently construct a pavement will influence not only the cost of a project but also the quality of the final pavement.

When multiple lifts of asphalt mix are required, the location of the joints in all lifts must be considered to ensure the joints are staggered. With joints placed in the surface course, care must be taken with the staging to ensure the joints are placed at the edges of the lanes and not in the wheel path. Joints placed in the wheel path are particularly vulnerable to deterioration under the stresses of traffic loads.

When cold joints are required, workmanship is the most important factor for determining the quality of a longitudinal joint. Care must be taken to ensure the proper amount of tack coat is placed against the cold joint. Sufficient asphalt material must be placed at the joint to provide adequate compaction and a uniform surface between the two lanes (avoid starving the joint). Care must also be taken when rolling the area along the unconfined edge of the asphalt mat to ensure compaction occurs without squeezing the lift and thinning it out. Contractors are advised to follow the specification requirements and the best practices available from industry sources to carry out their work.

OFFSET TO TEMPORARY CONCRETE BARRIER

Access to the work will often influence the quality of construction. Similarly, when construction takes place behind barrier wall, the quality of longitudinal joints is influenced by the offset from the joint to the temporary concrete barrier wall. The amount of space required between the barrier wall and a joint varies somewhat depending upon the type of paver and compaction equipment being used. In general the desirable offset from the barrier to the pavement joint is approximately 1500 mm. In areas where space is limited, the minimum offset is 300 mm. For work such as structure rehabilitations, it may be necessary to relocate the barrier temporarily in order to obtain an appropriate amount of space in which to carry out the paving. To avoid the added cost of a temporary barrier relocation, it may be possible to co-ordinate the paving operations with the barrier relocation or removal. In either case, it would be necessary to include an operational constraint in the contract documents, alerting the contractor to any special staging requirements during the design and contract preparation stage of the project.

SURFACE COURSE PAVING

For any new highway, paving of all lifts of asphalt pavement should ideally be placed with echelon paving. This minimises the potential problems related to longitudinal joint cracks reflecting up through the surface. Where this is not possible, at a minimum we should strive to pave the surface course in echelon.

SCHEDULING

The time of year when the surface course paving is completed, can significantly influence the quality of the joints. Paving in cooler temperatures causes the material to cool at a faster rate especially at the unsupported joint which in turn makes it more difficult to compact and achieve density. This increases the potential for poor compaction along the free edges of the pavement. Unfortunately, often the first consideration is ignoring the temperature requirements of the specifications in favour of completing the paving. If it is anticipated that the surface course paving will occur after mid-October, consideration should be given to including operational constraints in the contract to defer surface course paving until the following year. If the surface course paving is deferred, the interim surface course frictional characteristics and structural capacity of the pavement are issues that should be discussed with the Geotechnical Section. In urban areas or in situations where a barrier is present, drainage and snow plowing should also be considered.

MIX DESIGN

On projects involving traffic staging with barrier walls or other restrictions that impact on the paving crew's ability to properly set up the longitudinal joint, it may be appropriate to consider specifying a Superpave 12.5 FC1 or FC2 fine graded mix (SP 111F10). In general, these mixes include more fine material which improves the workability of the mix, reducing segregation during placement.

On projects such as bridge replacements or rehabilitations, a fine graded mix may result in improved paving quality, especially where hand work is required.

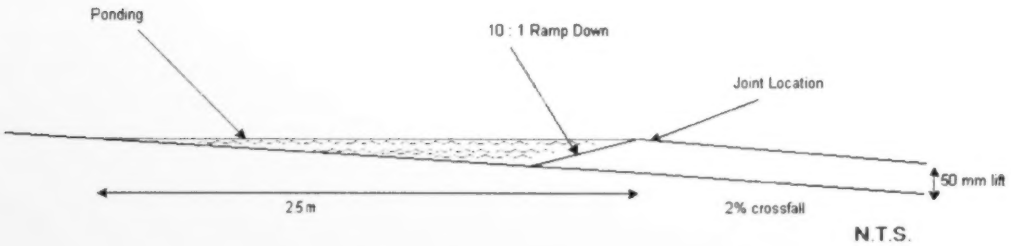
TEMPORARY RAMPING

Another method of improving the quality of the longitudinal joint is to ramp down the joint and then remove it prior to paving the next pass. This results in improved compaction of the material along the free edge. Typically, longitudinal ramps are constructed between lanes at 10:1 (H:V). While generally this method results in an improved joint, the cost of the additional material and equipment required to place and remove the ramping should be considered. These increased costs may be offset by

increased production, reduced cost for lane shifting, etc. The contract Special Provisions should address how these costs will be covered.

Additionally, vehicle handling needs to be considered when ramping and in particular the possible safety issues involving water ponding when paving on the low side. For example, ramping a 50 mm lift can result in ponding water over 2500 mm of the lane on the high side of the joint (Figure 1).

Figure 1 – Potential For Ponding Water



If safety concerns can be addressed, through a combination of operational constraints, temporary speed reductions, signage and or ramping, then it may be possible to accommodate temporary longitudinal ramping to at least reduce the number of transverse joints.

Improved Longitudinal Joint Construction Through New Technologies

Various agencies, including Ontario Ministry of Transportation, conducted trials to evaluate different techniques for improving longitudinal joint construction.

A financial premium is often incurred when the new materials and techniques are employed on a contract. The benefit of better quality joints may out-weigh the cost of using such materials and techniques. Again, designers need to conduct some cost/benefit analysis for the project. Where new technologies and methods are utilized on contracts, steps should be taken to document the trial, and to follow-up, monitoring performance over the life of the trial.

JOINT HEATERS

Photo 6 – Joint Heater (being pulled by farm tractor)

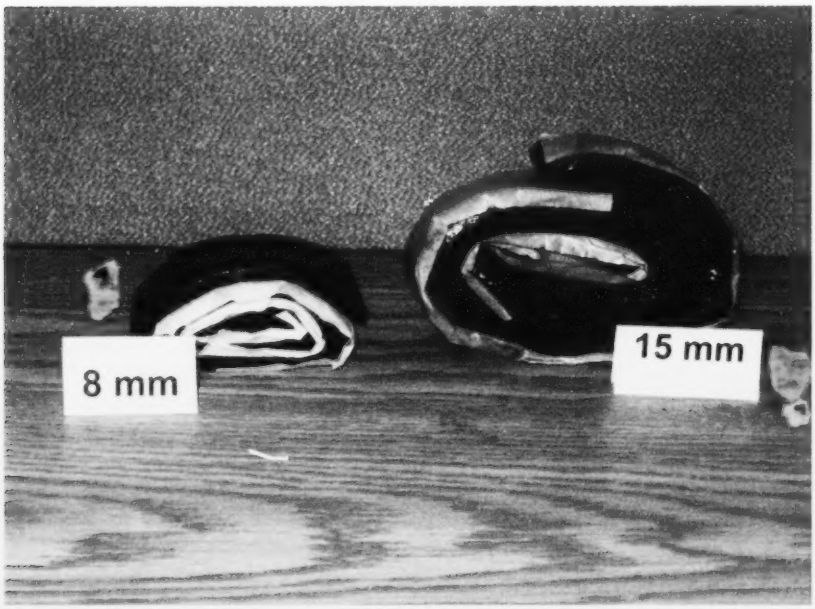
Equipment manufacturers have developed heaters (photo 6), compaction devices and adaptors for pavers to assist in compaction of the joint. While this new equipment can

help to improve cold joint quality, workmanship continues to be the most important factor. Currently, specifications do not contain any incentives for incorporating this technology, and when specified there are no acceptance criteria to ensure a specific level of quality is achieved. However, future density requirements tied to main lane paving may encourage the use of such devices to enhance the ability to meet the specification.

JOINT TAPE AND JOINT BOND MATERIAL

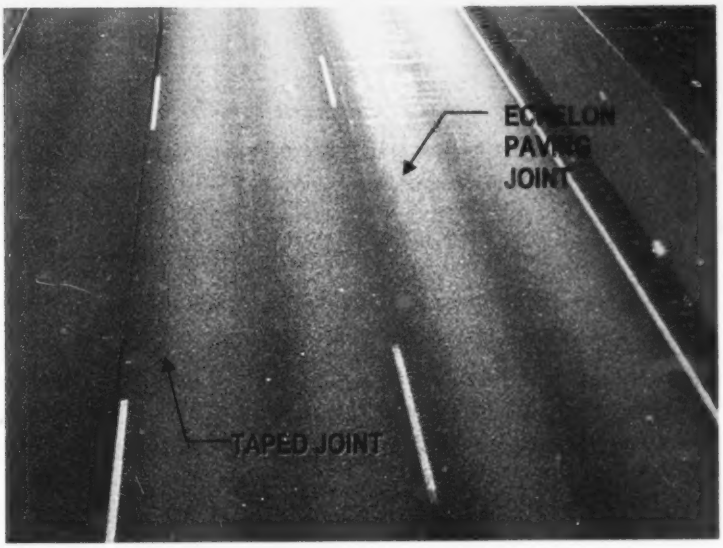
New materials such as joint tapes and extruded joint bond material have also been developed to increase the potential for improved performance of the joint.

Photo 7 – Tape Material



The asphalt tape (Photo 7) is applied to the cold joint in advance of the paver. At the time of writing this, the use of these tapes are still at the trial stage. In trials, there were ongoing issues with workmanship relating to the placement of the tape that may have influenced the success of the trials.

Photo 8 - Taped Joint vs Hot Joint



In photo 8 above, the joint on the right was paved in echelon, while tape was applied to the joint on the left. The photo was taken approximately three years after the matt was placed. From the photo it is obvious that the joint paved in echelon is performing much better than the joint where tape was applied. This relates directly to the fact that echelon paving results in both better density and bond at the joint, whereas use of the tape and bonding materials only address the bond between the interface of existing and new mats. Photo 9 shows the extruded joint bond material against the unconfined edge prior to placing the adjacent lane.

Photo 9 – Extruded Joint Bonding Material Along the Joint Edge

As with the other new technologies, contracts specifying the use of either tape of bonding material do not contain acceptance criteria to ensure a quality application and although

results to date have been good, we have observed workmanship issues that need to be addressed to ensure quality as these technologies evolve and new ones become available.

WARM MIX ASPHALT

New emerging technologies such as warm mix asphalt may help to improve the quality of the bond along longitudinal joints. In general, warm asphalts remain more workable with time at lower temperatures than hot mix. This allows for longer period for compaction and a stronger bond should be possible along the centreline joint, and higher levels of density can be attained.

A number of proprietary processes have emerged for making warm mix asphalt. In general, additives are added to the asphalt cement and/or changes to production processes. Processes vary by manufacturer, but generally involve the introduction of moisture into the mix to improve workability or expansion of the asphalt cement.

This technology is likely to become increasing more common. In addition to the more obvious advantages of a reduction of emissions and energy because of the lower mixing and placing temperature, there is a reduction in the oxidization of the asphalt cement when mixed at the lower temperatures. Additionally, warm mix asphalt technologies will permit longer haul distances and will allow the paving to be carried out at lower temperatures. At this point, the ministry's experience with warm asphalt is limited.

HOT IN-PLACE RECYCLING

Hot in-place recycling (HIR), has been used to resurface pavements exhibiting surficial distresses, (i.e., ravelling, coarse aggregate loss, and slight to moderate cracking) during the 1990's. Since 2003, awarding of contracts utilizing the rehabilitation technique has stopped due to the unavailability of the HIR paving trains in the province.

HIR process involves heating the existing asphalt pavement, till it is 80 to 130°C and is scarified. This heated loose material is then mixed with a rejuvenator, fine aggregate and/or admixture as required to get the existing material to the desired material properties and re-laid and compacted.

The performance of the HIR pavements has been comparable to conventionally rehabilitated pavements. Although this process only treats the top 40 to 50 mm of the pavement and does not mitigate reflection cracking or instability rutting, it was routinely observed that the majority of longitudinal and centreline cracks have not reflected through. This may be due to all HIR joints being formed hot, eliminating cold joints and allowing for additional compaction at the longitudinal joint.

Longitudinal Joint Maintenance/ Repairs

There are a few options to address longitudinal joint deterioration. However, repairs to longitudinal joints can be costly, and difficult to perform without impacting on traffic. Traffic control is often a major component of the repair cost. Not surprisingly, the need to control traffic also has significant adverse impacts on the travelling public. If longitudinal joint deterioration is addressed early, further deterioration is arrested resulting in a less expensive and more effective repair.

ROUT AND SEAL

Rout and seal (photo 10 and 11) is an effective method of repairing single, well defined longitudinal cracks. This repair method is also used to repair transverse thermal cracking and reflective cracking. Rout and seal is not an effective method for repairing longitudinal cracks that are poorly compacted or where ravelling is occurring.

Photo 10 - Joint Routing

Photo 11 - Joint Sealing

PATCHING

Where multiple cracks develop and potholing occurs, cold patch is used to fill the potholes. When severe pot-holing occurs, milling and paving strips is an approach that has often be used to repair deterioration. A disadvantage with the strip repair method is that two longitudinal cold joints are created. Uniform compaction of the strip is generally not difficult to achieve because both edges of the patch are restrained, however

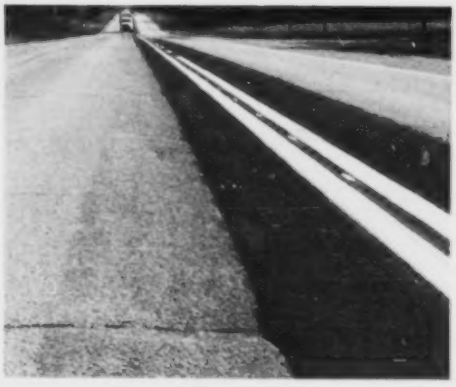
creating a flush surface can be a challenge. Joint heaters can be considered to heat both adjacent edges to improve the joints.

MICRO-SURFACE STRIP REPAIRS

More recently micro-surfacing strips (photo 12 and 13) have been used to repair deteriorated areas around the centreline. This is a relatively new approach used to treat deteriorated joints and while it shows great promise, the longevity of this repair technique is currently being monitored.

Photo 12 - Micro-surfacing Strip Repair

Photo 13 – Micro-surfaced Joint



Conclusions

Echelon and tandem paving are the most effective methods of eliminating longitudinal cold joints. The practicality of using these paving methods depends primarily upon traffic volumes, property access requirements, production capacity and equipment availability. Given the improved joint quality, and reduction in maintenance required, both options should be considered. While the feasibility of either option may not be fully known at the early stages of design, care should be taken in order not to preclude either method during the planning and environmental approval stages of the project.

In situations where echelon or tandem paving can be accommodated on an existing roadway, premium costs will likely be incurred. However, these costs are usually offset by superior joint performance, reduced maintenance costs during the pavement life and reduced inconvenience to drivers over the life of the pavement.

In cases where longitudinal cold joints can not be eliminated, the quality of the joint can be improved with attention to detail during the project planning stage. Careful project planning is an important part of ensuring the project environment is conducive to the required paving operations. Additionally, use of joint heaters, joint tapes and other non-traditional measures should be considered by the designers in consultation with the Geotechnical Section and the Contracts Section. The quality of workmanship and following good practices during paving still remain key to ensuring good joint performance and durability of the pavement.

Recommendations

It is recommended that regions carefully consider all opportunities that would facilitate paving in echelon or tandem paving. Selection of projects should consider impacts to traffic and property, premium costs as well as the improvement in quality. In situations where neither approach is feasible, care should be taken to ensure barriers to good workmanship are not built into the project.

Designers are key to ensuring opportunities for echelon paving are not overlooked during the early stages and it is recommended that the planning process review opportunities for this in the early planning and design stages in consultation with the Traffic Section, Geotechnical Section, and Contracts Section.

Where opportunities will not permit echelon or tandem paving and barriers to quality construction can not be eliminated, designers could consider specifying use of new technologies to improve the long term performance of the longitudinal joints. As new technologies and equipment emerge, greater opportunities will exist to improve the quality of construction joints, and in particular the longitudinal centreline joints. Where new technologies are utilized, the work should be monitored over time to confirm the effectiveness of the approach.

To encourage proper construction methods and effective usage of the new technologies a non-destructive test method and acceptance specification should be developed to encourage better construction and attention to quality joints for future work.

Appendix A: Constructability Task Group

The Pavement Constructability Task Group includes members from MTO and OHMPA.

PARTICIPANTS:

Alexander (Sandy) Brown – Ontario Hot-mix Producers Association – Co-Chair
Kai Tam – Ontario Ministry of Transportation – Co-Chair

Joe Bunting – Miller Paving Limited
Murray Ritchie – Murray Group Limited
Gary Sidlar – The Hard Rock Group
Michael Greco – Lafarge Canada Inc.
Pamela Marks – Ontario Ministry of Transportation
Steven McInnis – Ontario Ministry of Transportation

Appendix B: Project Stages - Stakeholders /Key Activities/ Considerations

This Appendix outlines the various stages of a typical highway reconstruction project. It identifies possible stakeholder groups and outlines some of the key activities and considerations required when considering echelon or tandem paving.

Given the great amount of variability in project complexity from region to region the information contained in the appendix should not be considered complete or all encompassing.

PLANNING STAGE

During the planning stage of a highway design project, few details have been worked out and the focus is on identifying the issues and concerns. At this stage it will not be known if echelon paving is a viable option, however the designer should consider staging the work in a manner that will allow echelon paving. For projects with large asphalt quantities it is recommended that the potential for lane/road closures should be raised during this stage, so that echelon or tandem paving remain potential solutions.

For existing highways, staging work in a manner that will allow echelon paving may require temporary road closures. The road closures may result in the need to establish detours utilizing municipal, township or county road network. The road closure may impact on a number of issues that should be addressed during public and municipal consultation and be addressed during the EA process.

Impact on property access, access to commercial businesses, school bus routes, mail delivery and emergency services etc. all require consideration.

Regardless of paving method, the project should be scheduled to permit/require the surface course to be paved during optimal weather conditions.

STAKEHOLDER CONSULTATION

Internal:

Planning and Design – Project Manager
Environmental Unit
Traffic Section
Geotechnical Section

External:

Municipality
Emergency Services
Public

KEY ACTIVITIES

- Determine preliminary estimate of hot-mix paving item quantities.
- Determine if echelon paving is possible or practical.
- Determine preliminary schedule for paving operations.
- Explore potential time and duration for potential closing/lane reductions highways.
- Consultation with local municipalities regarding detours and use of local roads.
- Discuss project with emergency services.
- Identify potential impacts (businesses, school buses, mail service etc.)
- Identify potential for highway closure and traffic diversion in EA process.

POSSIBLE CONSIDERATIONS

- Determine whether property access concerns can be addressed by night time or weekend closures.

PRELIMINARY DESIGN STAGE

During this stage of the project, more detail is available for the project. Some issues have been identified and discussed with the municipality and other key stakeholders. Project staging is better understood but not yet finalized.

During the EA process, clearly identify the potential for intermittent short duration closures that may be used during the paving phase of the contract.

STAKEHOLDERS

Internal:

Planning and Design – Project Manager
Environmental Unit
Traffic Section
Geotechnical Section
Contracts Section

External:

Municipality
Emergency Services
Public

KEY ACTIVITIES

- Refine preliminary estimate of hot-mix paving item quantities.
- Refine estimate of possible duration for paving operations.
- Refine estimate timing and duration for potential closing highways.
- Identify potential concerns with highway closure and traffic diversion.
- Continue consultation/discussion with local municipalities regarding use of local roads.
- Determine need for noise by-law exemption to permit night-time paving.
- Examine mitigation options, such as additional signage, newspaper notices, and installation of traffic signals.
- Consider staging options for construction.
- Negotiation with stakeholders
- Documentation of environmental issues/concerns
- Prepare/submit TESR

POSSIBLE CONSIDERATIONS

- Determine whether paving in echelon is likely to be feasible given hot-mix quantities, traffic volumes, availability of local detour routes, property access requirements.
- Determine whether property access concerns can be addressed by night time or weekend closures.

- Identify any changes that have occurred since initial consultation with stakeholders.

DETAIL DESIGN STAGE

During this stage the finer points of the project are identified and addressed. Buy-in from key stakeholder is being sought/finalized. The contract documents are being assembled for tendering.

STAKEHOLDERS

Internal:

Planning and Design – Project Manager
Environmental Unit
Traffic Section
Geotechnical Section
Contracts Section

External:

Municipality
Emergency Services
School Boards
Public

KEY ACTIVITIES

- Prepare final estimate of hot-mix paving item quantities.
- Discuss/confirm opportunities for use of new paving technologies with Geotechnical and Contracts staff.
- Prepare final estimate of duration for paving operations.
- Confirm whether paving in echelon is feasible given hot-mix quantities, traffic volumes, availability of local detour routes, property access requirements.
- Develop staging/traffic control strategy.
- Fine tune estimates of potential time and duration for potential highway closures.
- Continue consultation/discussion with local municipalities regarding use of local roads.
- Determine need/requirements for municipal noise by-law exemption to permit night-time paving.
- Obtain by-law exemption if required.
- Discuss schedule for road closures with emergency service providers, school boards etc.
- Negotiations with other stakeholders
- Examine mitigation options, such as additional signage, newspaper notices, installation of traffic signals
- Documentation of environmental issues/concerns
- Prepare/submit TESR
- Develop contract Special Provisions

POSSIBLE CONSIDERATIONS:

- Review and insert appropriate specifications into construction contract.
- Develop staging to minimize the number of joints. This is particularly important in the surface course paving.
- Determine hot-mix types for various components (consideration should be given to using the same mix types for all components on any given course, i.e. consideration should be given to ensuring the shoulders are paved with the same materials as the mainline to facilitate paving in echelon.)
- For projects requiring milling, determine if the pavement structure can support the anticipated traffic with out the surface course pavement being in place.
- Consider the potential for a contractor change proposal to impact on staging. Where practical, attempt to maintain flexibility to accommodate changes.

CONSTRUCTION STAGE

During this stage of the project, Contracts Section or Operational Services takes on the primary responsibility for the project. Care should be taken to identify commitments that have been made to stakeholders.

STAKEHOLDERS

Internal:

Planning and Design – Project Manager
Environmental Unit
Traffic Section
Geotechnical Section
Contracts Section

External:

Municipality
Contractor
Contract Administrator
Emergency Services
School Boards
Public

KEY ACTIVITIES

- Confirm contractors schedule for paving operations.
- Address details for using local detour routes and maintaining property access where required.
- Ongoing consultation/discussion with local municipalities regarding use of local roads.
- Confirm schedule for road closures with emergency services, school boards etc.
- Review change proposals in light of impact on construction and in careful consideration of previous commitments and obligations.

POSSIBLE CONSIDERATIONS

- Review traffic operations on highway and detours routes.

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